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EP-A- 0 212 691
FR-A- 2 286 888

PROCEEDINGS OF THE 3rd INTERNATIONAL SYMPOSIUM ON VLSI SCIENCE AND TECHNOLOGY, THE ELECTROCHEMICAL SOCIETY, vol. 89, no. 9, S. Broydo AND C.N. Osburns Ed., September 1989; D.A.WEBB et al.: "Silicon dioxide films produced by PEVCD of TEOS and TMCTS" page 571

JOURNAL OF VACUUM SCIENCE & TECHNOLOGY, section B, vol. 5, no. 6, November-December 1987, Woodbury, NY, US; F.S.BECKER et al.: "Low-pressure deposition of high-quality SiO₂ films by pyrolysis of tetraethylorthosilicate" page 1555

THIN SOLID FILMS, vol. 97, no. 1, November 1982, Lausanne, CH; U.MACKENS et al.: "Plasma-enhanced chemically vapour-deposited silicon dioxide for metal/oxide/semiconductor structures on InSb"

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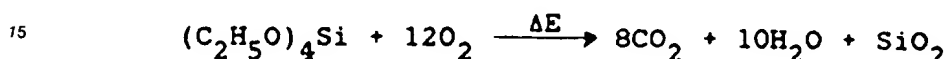
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Description

BACKGROUND OF THE INVENTION

Over the past twenty years, tetraethoxysilane (TEOS) has been extensively used as a liquid source for the deposition of silicon dioxide. Low pressure chemical vapor deposition (LPCVD) techniques have in general been employed in which TEOS is thermally decomposed at approximately 725 °C in the presence of oxygen. More recently, plasma-enhanced chemical vapor deposition (PECVD) techniques, using either microwave or radio-frequency (rf) energy sources, have been employed to facilitate the decomposition of TEOS in the presence of oxygen at temperatures down to 20 °C.

For both LPCVD and PECVD techniques, the overall decomposition reaction can, in general, be represented by the following equation:



If this oxidation process is incomplete, carbon monoxide may also be a product and the resulting oxide films may contain mobile ions such as carbon, hydroxyl and silicon-hydrogen groups.

As disclosed in US-A-5 023 206, the compressive stress of silicon dioxide films using silane and nitrous oxide can be reduced by the addition of small amounts of fluorine-containing compounds such as CF₄, SiF₄, and NF₃. In the case of SiF₄, the deposition rate increased with increasing flow of the additive while with NF₃ the rate decreased. This latter observation is not surprising since it is well established that NF₃ is an excellent oxide etchant that produces •NF₂ and •F radicals in an rf plasma environment.

For single-wafer plasma-enhanced chemical vapor deposition (PECVD) systems, it is essential to have a high deposition rate, usually above about 300nm (3000 Angstroms) per minute, in order to compete with batch systems. This is conventionally obtained using pressures of 266 N/m² (two torr) and higher. However, these relatively high pressures result in extensive gas phase nucleation and cause a "snow" of SiO₂ throughout the reaction chamber. The tendency to create "snow" has conventionally been counteracted by elaborate inert gas "curtains" to confine the deposition, together with frequent in-situ cleaning of the chamber. The conventional low pressure reaction is very clean, but the deposition rate is unacceptable for single-wafer reactors. Therefore, a need has arisen for a clean, single wafer, PECVD system for the deposition of SiO₂ with an acceptably high deposition rate.

SUMMARY OF THE INVENTION

One aspect of the present invention comprises a process for depositing a layer of a silicon-containing compound on a wafer and a composition as defined in claim 1. The wafer is disposed in a chamber evacuated to a low pressure, such as a pressure less than about 1064 N/m² (eight torr). At least two gas reactants are introduced to the chamber, including a gaseous organosilicon compound and nitrogen trifluoride. These reactants will deposit the silicon-containing compound on the wafer at a rate that is enhanced over the deposition rate that would be obtained without using nitrogen trifluoride. Given the reduction in deposition rate reported by us for the use of nitrogen trifluoride with of silane and nitrous oxide, the enhancement of the deposition rate with the use of nitrogen trifluoride is a surprising result.

The above process has application to the deposition of silicon dioxide, silicon nitride and polysilicon. Where silicon dioxide is the depositing film, it is preferred that the organosilicon compound comprise an organosiloxane such as tetraethoxysilane (TEOS) or an alkyl cyclosiloxane such as tetraethylcyclotetrasiloxane or tetramethylcyclotetrasiloxane.

It is further preferred that oxygen be introduced into the chamber together with the organosilicon compound and nitrogen trifluoride reactant, as further enhancements in the deposition rate have been observed with this additive. In one embodiment, the oxygen introduced in the chamber may first be bubbled through a TEOS liquid, with vaporized TEOS being carried into the chamber by oxygen. The energy for the chemical reaction necessary for film deposition can be lent to the reactants through the formation of a plasma by radio frequency, microwave or magnetically enhanced techniques. Alternatively, the deposition can proceed thermally using low-pressure chemical vapor deposition (LPCVD).

It has been found that the introduction of between four and 70 volumetric percent of nitrogen trifluoride to a mixture including from two to 70 volumetric percent organosilicon compound results in an enhanced deposition rate. In the case of TMCTS, at least a five to one molar ratio of NF₃ to TMCTS is preferred to

obtain the optimum deposition rate. For TEOS, a molar ratio of NF_3 to TEOS of at least ten to one is preferred for a good deposition rate in excess of 500nm (5000 Angstroms) per minute at pressures below 133 N/m² (1 torr). Oxygen may be introduced into the chamber in an amount ranging between 25 and 90 percent by volume.

- 5 In another aspect of the invention, the process may be carried out at pressures below 133 N/m² (1.0 torr) to achieve the filling of topographical features having high aspect ratios. Aspect ratios of topographical features filled by conventional TEOS systems measure no more than 0.7 to 0.8. On the other hand, according to the process of the invention, a filling of features having aspect ratios in excess of 1.0 can be obtained with a film of good structural integrity. The use of NF_3 as a reactant may also lower mobile ion
10 concentration and surface-state charge density in the deposited film.

DETAILED DESCRIPTION OF THE INVENTION

- FIGURE 1 is a schematic representation of apparatus to carry out the invention, the apparatus preferably including a plasma-enhanced chemical vapor deposition (PECVD) reactor shown generally at 10. Chamber 10 is hermetically sealed and is evacuated by a vacuum pump 12 connected to the interior of chamber 10 by a vacuum line 14. The interior of chamber 10 is evacuated to a pressure in the range from about 53,2 N/m² (0.4 torr) to about 1064 N/m² (8 torr). Inside the reactor vessel 10, a wafer W is attached by clips or the like (not shown) to a grounded plate 16. Plate 16 is suspended over a "shower head" manifold 18 that is connected to an rf energy source 20. It is preferred that plate 16 be heated. While the illustrated embodiment involves the use of an rf-generated plasma, the invention also has application to reactors in which a plasma is generated by other means, such as magnetically-assisted rf or microwave, and further applies to nonplasma reactors such as a low-pressure chemical vapor deposition (LPCVD) reactor.

- 25 A source 22 of nitrogen trifluoride is connected as by means of a tube 24 to the manifold 18. A tank 26 of oxygen is connected through a tube 28 to the bottom of a vessel 30 that contains an amount of tetraethoxysilane (TEOS) in liquid form. In other embodiments, the TEOS can be replaced with another alkyl oxysilane or an alkyl cyclosiloxane, such as 1,3,5,7 tetraethylcyclotetrasiloxane (TECTS) or 1,3,5,7 tetramethylcyclotetrasiloxane (TMCTS).

- 30 Oxygen bubbles out of tube 28 and picks up TEOS vapor. The oxygen carries TEOS vapor with it through a

BRIEF DESCRIPTION OF THE DRAWINGS

- 35 Further aspects of the invention and their advantages may be discerned with the aid of the following detailed description taken in conjunction with the drawings in which:

FIGURE 1 is a schematic diagram of a plasma-enhanced chemical vapor deposition reactor and associated equipment according to the invention;

- 40 FIGURE 2 is a graph of silicon dioxide deposition rate versus flow rate of nitrogen trifluoride with TEOS used as a gaseous organosilicon reactant;

FIGURE 3 is a graph of silicon dioxide deposition rate versus flow rate of nitrogen trifluoride where TMCTS is used as a gaseous organosilicon reactant;

FIGURE 4 is a schematic sectional view of a wafer having high-aspect-ratio features and an oxide film deposited thereon by a process according to the prior art; and

- 45 FIGURE 5 is a schematic cross sectional view of a wafer having high-aspect-ratio features and an oxide film deposited thereon according to the invention.

tube 32 to the shower head manifold 18, where the TEOS mixes with the nitrogen trifluoride gas provided by tube 24. This mixture then exits the manifold 18 as shown by arrows 34. The rf energy applied to the manifold 18 causes a plasma to be generated in a space between the shower head 18 and the wafer W.

- 50 In another embodiment, the TEOS may be introduced directly into the manifold 18 as a vapor instead of being carried by the oxygen from tank 26. While it is preferred that oxygen be used in the reaction mixture, it is not absolutely essential. Further, a carrier gas for the TEOS may comprise any other inert gas such as helium, argon or nitrogen. Suitable valves and meters (not shown) are used to control the flow rates of the reactants into the chamber 10.

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EXAMPLE I

A series of sixteen experiments were performed to demonstrate the effectiveness of nitrogen trifluoride in increasing the deposition rate of silicon dioxide from TEOS. The results of these experiments and their parameters are set out in Table I.

TABLE I

Exp. No.	O ₂ Flow, sccm	F. Flow, sccm	Pressure, Nm ⁻² (torr)	rf Power, watts	Bubbler / Vapor nm/min (Å/min)	Depos. Rate, nm/min (Å/min)	Refr. Index
1.	175	0	266 (2)	230	Bubbler	285 (2,850)	1.44
2.	175	CF ₄ / 20	266 (2)	230	Bubbler	245 (2,454)	1.46
3.	175	SiF ₄ / 20	266 (2)	230	Bubbler	292 (2,922)	1.44
4.	175	NF ₃ / 20	266 (2)	230	Bubbler	1372 (13,721)	
5.	175	0	399 (3)	230	Bubbler	650 (6,507)	
6.	175	NF ₃ / 32	399 (3)	230	Bubbler	1661 (16,611)	
7.	175	0	532 (4)	230	Bubbler	1353 (13,531)	
8.	175	CF ₄ / 20	532 (4)	230	Bubbler	1336 (13,369)	
9.	175	SiF ₄ / 20	532 (4)	230	Bubbler	1341 (13,411)	
10.	175	NF ₃ / 20	532 (4)	230	Bubbler	1507 (15,078)	
11.	30	0	79,8 (0.6)	50	Vapor	131 (1,316)	1.43
12.	0	NF ₃ / 5	79,8 (0.6)	50	Vapor	229 (2,295)	1.45
13.	5	NF ₃ / 5	79,8 (0.6)	50	Vapor	286 (2,869)	
14.	0	NF ₃ / 7	79,8 (0.6)	50	Vapor	292 (2,922)	
15.	0	NF ₃ / 10	79,8 (0.6)	50	Vapor	345 (3,455)	
16.	0	NF ₃ / 20	79,8 (0.6)	50	Vapor	504 (5,041)	1.42

For the first ten experiments, TEOS was introduced into a single-wafer PECVD reactor at a flow rate of approximately ten standard cubic centimeters/minute (sccm). The flow rate of TEOS for the last six experiments in the range of three to five sccm. In a first, control experiment, no fluorine source was used at all. The power applied to the shower head electrode was 230 watts and oxygen was bubbled through the bubbler at a flow rate of about 175 sccm. Pressure was held at 266 N/m² (two torr). The deposition rate thus achieved was 285 nm/min (2850 Angstroms per minute).

Experiments 2 and 3 were similar to experiment 1, except for the addition of non-nitrogenated fluorine sources, such as tetrafluoromethane and tetrafluorosilane. These fluorine sources had relatively little effect on the oxide deposition rate.

In the fourth experiment, nitrogen trifluoride was introduced into the reactor at 20 sccm, or at a molar ratio with respect to the TEOS in the range of about 4:1 to 7:1. As may be seen, the deposition rate increase is dramatic. In view of the negative influence that nitrogen trifluoride has on silane as a silicon-depositing source, this dramatic increase in deposition rate was surprising.

Experiments 5 and 6 were carried out at a pressure of 399 N/m² (three torr) with experiment 5 having no fluorine source while experiment 6 introduced nitrogen trifluoride at 32 sccm. The difference in oxide deposition rate was over 1000 nm/min (10,000 Angstroms per minute).

Experiments 7 through 10 were conducted at a pressure of 532 N/m² (four torr). Experiment 7 used no fluorine source at all, while experiments 8 and 9 introduced 20 sccm of tetrafluoromethane and tetrafluorosilane, respectively. As in the case of the experiments conducted at 266 N/m² (two torr), there was little effect on the deposition rate by these two fluorine sources. Once again, as shown by Experiment 10, a substantial increase in deposition rate was noted when nitrogen trifluoride was used as the fluorine source.

Experiments 11 through 16 were conducted at a substantially reduced pressure of 79,8 N/m² (0.6) torr. A base deposition rate without any fluorine source was established by Experiment 11 at about 130 nm/min (1300 Angstroms) per minute. This deposition rate is too low to be competitive with batch reactors. Experiments 12 through 16 added increasing amounts of nitrogen trifluoride. With no oxygen, a dramatic increase in the deposition rate was recorded for nitrogen trifluoride at only 5 sccm, as is shown for Experiment 12. The addition of 5 sccm oxygen somewhat enhances the deposition rate further, as shown by Experiment 13. Further advances in deposition rate were noted by further increases in the nitrogen trifluoride flow rate. A deposition rate in excess of 500nm/min (5000 Angstroms per minute) were noted when the flow rate of nitrogen trifluoride was approximately 20 sccm, roughly corresponding to a molar ratio of about five to one with respect to the TEOS.

While the exact decomposition mechanism leading to these enhanced deposition rates is not fully understood, it is likely that atomic fluorine is consumed by extraction of hydrogen from the alkyl groups on the organosilicon compounds. This could explain why the fluorine does not appear to etch the film deposited. The failure of CF₄ and SiF₄ to have a significant effect in deposition rate implies that some fragment of NF₃ is involved other than fluorine itself, such as NF₂. The atomic ratio of oxygen to silicon for these films is shown by Rutherford Back Scattering (RBS) to be 2:1 as expected for a silicon dioxide film. Fluorine was, however, not detected in the RBS tests. Infrared transmission spectra of several films deposited with NF₃ showed the expected bands for SiO₂.

The data for Experiments 12, 14, 15 and 16 are plotted in the graph shown in FIGURE 2. This graph discloses a linear relationship between the flow rate of nitrogen trifluoride and the deposition rate of silicon dioxide up to a ten to one molar ratio of NF₃ to TEOS.

EXAMPLE II

TMCTS was used as the organosilicon gaseous compound and was introduced into the same LPCVD reactor with nitrogen trifluoride. An oxygen flow rate was established at 158 sccm. The TMCTS flow rate was metered at between four and five sccm. Rf power was applied to the shower head manifold at 150 watts, and the pressure was held at 73,15 N/m² (0.55 torr).

The results of a series of experiments with these conditions are graphed in FIGURE 3. Again, a linear relationship is established between the deposition rate and the flow rate of NF₃ up to approximately 25 sccm, or up to approximately a five to one molar ratio of NF₃ to TEOS. The curve thereafter flattens out, with very similar deposition rates being noted for 30 and 35 sccm of NF₃.

The invention also allows the filling of topographical features having a higher aspect ratio that has been conventionally possible. FIGURE 4 is a highly magnified schematic cross sectional view of a silicon wafer 50 having a plurality of trenches 52 formed therein. An oxide layer 54 was deposited on the wafer 50 from TEOS according to a conventional process. A plurality of voids 56 were formed such that the trenches 52

were not completely filled. The limit of aspect ratios of topographical features capable of being filled by conventional TEOS processes has been found to be in the range of 0.7 to 0.8, where the aspect ratio is calculated as the ratio of depth over width of the feature. The oxide layer 54 produced in FIGURE 3 was produced with a flow rate of approximately ten sccm of TEOS and 175 sccm of O₂, but without any nitrogen trifluoride being introduced into the reactor.

FIGURE 5 is a highly magnified schematic cross sectional view of a silicon substrate 50 on which a plurality of metal leads 62 have been deposited. A plurality of trenches 64 are formed in between the metal lead 62 that have aspect ratios of approximately 1:1. A layer 66 of oxide was deposited on this structure in a PECVD reactor with a flow rate of 175 sccm of oxygen, 10 sccm TEOS and 10 sccm nitrogen trifluoride. As is seen, the trenches 64 were completely filled with the oxide 66, with voids 68 only occurring well above the trenches 64.

This enhanced capability to fill high aspect ratio features may result because the oxide deposition with NF₃ is more anisotropic. Therefore, there is a reduced sidewall deposition. Aspect ratios up to at least 1.0 can be filled with oxide of good integrity, using O₂ to NF₃ ratios of less than about 6:1, and more preferably about 3:1.

The present invention has general application to any deposition system using an organosilicon compound that contains an aliphatic C-H group. Organosilicon sources for Si₃N₄ and polysilicon films are chemically similar to those for the oxide thin films above discussed. Hence, the addition of NF₃ to the reaction mixture is expected to enhance deposition rates for these types of films also. Alternative energy sources for making plasma include microwave-induced remote plasma and magnetically enhanced plasmas by magnetron or electron cyclotron resonance. Where a silicon nitride film is desired to be deposited, ammonia, nitrogen or another source of nitrogen is also introduced into the reactor to obtain the required stoichiometry.

In summary, a novel process for depositing silicon-containing films that enhance deposition rates has been discovered that employs the use of nitrogen trifluoride in conjunction with organosilicon gaseous compounds. At low pressures, the process also results in filling topographical features having higher aspect ratios than have been heretofore achieved.

Claims

1. A composition for depositing a layer of silicon-containing compound on a substrate within a low-pressure reactor, comprising:
 - between two and seventy percent by volume of an organosilicon gas compound; and
 - between four and seventy percent by volume of nitrogen trifluoride.
2. The composition of claim 1, wherein said organosilicon gas compound comprises an organosiloxane.
3. The composition of claim 2, wherein said organosiloxane comprises tetraethoxysilane.
4. The composition of claim 3, wherein the molar ratio of nitrogen trifluoride to tetraethoxysilane is at least four to one.
5. The composition of claim 2, wherein said organosilicon gas compound comprises an alkylcyclotrisiloxane.
6. The composition of claim 2, wherein said alkylcyclotrisiloxane comprises a tetraethylcyclotetrasiloxane.
7. A process for depositing a layer of a silicon-containing compound on a wafer, comprising the steps of:
 - disposing the wafer in a chamber evacuated to a low pressure;
 - introducing a gaseous organosilicon compound into the chamber;
 - introducing nitrogen trifluoride into the chamber;
 - responsive to said steps of introducing the organic compound and nitrogen trifluoride into the chamber, reacting the gaseous organosilicon compound and the nitrogen trifluoride; and
 - responsive to said step of reacting, depositing the silicon-containing compound on the wafer at a rate greater than a corresponding depositing rate obtained without using nitrogen trifluoride.
8. The process of claim 7, and further comprising the step of regulating the pressure inside the chamber to be no more than about 532 N/m² (four torr).

9. The process of claim 7, and further comprising the step of regulating the pressure inside the chamber to be less than about 133 N/m² (1.0 torr).
10. The process of claim 7, and further comprising the step of introducing oxygen into the chamber.
11. The process of claim 10, and further comprising the steps of:
bubbling oxygen through a liquid organosilicon compound;
vaporizing the organic liquid compound into the oxygen to yield the gaseous organosilicon compound; and
carrying the gaseous organosilicon compound into the chamber with the oxygen.
12. The process of claim 7, and further comprising the step of creating a plasma in order to react the introduced gases.
13. The process of claim 7, and further comprising the step of depositing the silicon-containing compound using low pressure chemical vapor deposition.
14. The process of claim 7, and further comprising the steps of:
introducing the nitrogen trifluoride into the chamber in amounts ranging from four to seventy percent by volume; and
introducing the gaseous organosilicon compound into the chamber in amounts ranging from two to seventy percent by volume;
15. The process of claim 7, and further comprising the steps of:
introducing a second nitrogen-containing gas into the chamber; and
depositing the layer on the wafer to include silicon nitride.
16. A process for depositing a layer of silicon-containing compound on a wafer surface having topographical features of high aspect ratio, comprising the steps of:
disposing the wafer in a chamber evacuated to a pressure below about 135 N/m² (one torr);
introducing a gaseous organosilicon compound into the chamber;
introducing nitrogen trifluoride into the chamber; and
reacting the organosilicon compound with the nitrogen trifluoride to deposit the layer of silicon-containing compound on the surface such that voids in the layer are not formed.
17. The process of claim 16, and further comprising the step of filling topographical features on the wafer having an aspect ratio greater than or equal to 1,0.
18. The process of claim 16, and further comprising the step of introducing oxygen into the chamber.
19. The process of claim 16, and further comprising the step of introducing oxygen and the nitrogen trifluoride into the chamber in a volumetric ratio not exceeding about six to one.

Patentansprüche

1. Zusammensetzung zum Ablagern einer Schicht einer siliziumhaltigen Verbindung auf einem Substrat in einem Niederdruckreaktor, enthaltend:
zwischen 2 und 70 Vol.-% einer Organosilizium-Gasverbindung und
zwischen 4 und 70 Vol.-% Stickstofftrifluorid.
2. Zusammensetzung nach Anspruch 1, bei welcher die Organosilizium-Gasverbindung ein Organosiloxan ist.
3. Zusammensetzung nach Anspruch 2, bei welcher das Organosiloxan Tetraethoxysilan ist.
4. Zusammensetzung nach Anspruch 3, bei welcher das molare Verhältnis von Stickstofftrifluorid zu Tetraethoxysilan wenigstens vier zu eins beträgt.

5. Zusammensetzung nach Anspruch 2, bei welcher die Organosilizium-Gasverbindung ein Alkylcyclotetrasiloxan ist.
- 5 6. Zusammensetzung nach Anspruch 2, bei welcher das Alkylcyclotetrasiloxan ein Tetraethylcyclotetrasiloxan ist.
7. Verfahren zum Ablagern einer Schicht aus einer siliziumhaltigen Verbindung auf einer Scheibe, enthaltend die Schritte:
Anbringen der Scheibe in einer auf einen niedrigen Druck evakuierten Kammer;
10 Einführen einer gasförmigen Organosiliziumverbindung in die Kammer;
Einführen von Stickstofftrifluorid in die Kammer;
Umsetzen der gasförmigen Organosiliziumverbindung mit dem Stickstofftrifluorid als Antwort auf die Schritte des Einführens der organischen Verbindung und des Stickstofftrifluorids in die Kammer; und
als Antwort auf den Umsetzungsschritt, Ablagern der siliziumhaltigen Verbindung auf der Scheibe mit
15 einer Rate, die größer als eine entsprechende Ablagerungsrate ist, die ohne Verwendung von Stickstofftrifluorid erhalten wird.
8. Verfahren nach Anspruch 7, ferner enthaltend den Schritt des Regelns des Drucks innerhalb der Kammer so, daß er nicht mehr als etwa 532 N/m² (4 Torr) beträgt.
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9. Verfahren nach Anspruch 7, ferner enthaltend den Schritt des Regelns des Drucks innerhalb der Kammer so, daß er weniger als etwa 133 N/m² (1,0 Torr) beträgt.
10. Verfahren nach Anspruch 7, ferner enthaltend den Schritt des Einführens von Sauerstoff in die Kammer.
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11. Verfahren nach Anspruch 10, ferner enthaltend die Schritte:
Hindurchsprudeln von Sauerstoff durch eine flüssige Organosiliziumverbindung;
Verdampfen der organischen flüssigen Verbindung in dem Sauerstoff zur Erzielung der gasförmigen Organosiliziumverbindung; und
30 Überführen der gasförmigen Organosiliziumverbindung in die Kammer mit dem Sauerstoff.
12. Verfahren nach Anspruch 7, ferner enthaltend den Schritt des Erzeugens eines Plasmas zur Erzielung der Reaktion der eingeführten Gase.
- 35 13. Verfahren nach Anspruch 7, ferner enthaltend den Schritt des Ablagerns der siliziumhaltigen Verbindung unter Verwendung der chemischen Dampfabscheidung bei niedrigem Druck.
14. Verfahren nach Anspruch 7, ferner enthaltend die Schritte:
Einführen des Stickstofftrifluorids in die Kammer in Mengen, die von 4 bis 70 Vol.-% reichen; und
40 Einführen der gasförmigen Organosiliziumverbindung in die Kammer in Mengen, die von 2 bis 70 Vol.-% erreichen.
15. Verfahren nach Anspruch 7, ferner enthaltend die Schritte:
Einführen eines zweiten stickstoffhaltigen Gases in die Kammer; und
45 Ablagern der Schicht auf der Scheibe so, daß sie Siliziumnitrid enthält.
16. Verfahren zum Ablagern einer Schicht aus einer siliziumhaltigen Verbindung auf einer Scheibenoberfläche, die topographische Merkmale mit hohem Schlankheitsverhältnis haben, enthaltend die Schritte:
Anbringen der Scheibe in einer Kammer, die auf einen Druck unterhalb etwa 135 N/m² (1 Torr)
50 evakuiert ist;
Einführen einer gasförmigen Organosiliziumverbindung in die Kammer;
Einführen von Stickstofftrifluorid in die Kammer; und
Umsetzen der Organosiliziumverbindung mit dem Stickstofftrifluorid zum Ablagern der Schicht aus der siliziumhaltigen Verbindung auf der Oberfläche so, daß in der Schicht keine Lücken gebildet werden.
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17. Verfahren nach Anspruch 16, ferner enthaltend den Schritt des Ausfüllens topographischer Merkmale auf der Scheibe, die ein Schlankheitsverhältnis größer oder gleich 1,0 haben.

18. Verfahren nach Anspruch 16, ferner enthaltend den Schritt des Einführens von Sauerstoff in die Kammer.

19. Verfahren nach Anspruch 16, ferner enthaltend den Schritt des Einführens von Sauerstoff und von Stickstofftrifluorid in die Kammer in einem Volumenverhältnis, das sechs zu eins nicht überschreitet.

Revendications

1. Composition pour le dépôt d'une couche d'un composé contenant du silicium sur un support dans un réacteur à basse pression comprenant :
entre deux et soixante-dix pour-cent en volume d'un composé gazeux organosilicium ; et
entre quatre et soixante-dix pour-cent en volume de trifluorure d'azote.

2. Composition selon la revendication 1, dans laquelle ledit composé gazeux organosilicium comprend un organosiloxane.

3. Composition selon la revendication 2, dans laquelle ledit organosiloxane comprend du tétraéthoxysilane.

4. Composition selon la revendication 3, dans laquelle le rapport molaire du trifluorure d'azote au tétraéthoxysilane est d'au moins quatre pour un.

5. Composition selon la revendication 2, dans laquelle ledit composé gazeux organosilicium comprend un alkylcyclsiloxane.

6. Composition selon la revendication 2, dans laquelle ledit alkylcyclsiloxane comprend un tétraéthylcyclotétrasiloxane.

7. Procédé de dépôt d'une couche d'un composé contenant du silicium sur une pastille, comprenant les étapes de :
la mise en place de la pastille dans une enceinte mise sous basse pression ;
l'introduction d'un composé organosilicium gazeux dans l'enceinte ;
l'introduction de trifluorure d'azote dans l'enceinte ;
en réponse auxdites étapes d'introduction du composé organique et du trifluorure d'azote dans l'enceinte, la réaction du composé organosilicium gazeux et du trifluorure d'azote ; et
en réponse à ladite étape de réaction, le dépôt du composé contenant du silicium sur la pastille à une vitesse supérieure à celle correspondant à un dépôt obtenu sans utilisation de trifluorure d'azote.

8. Procédé selon la revendication 7, lequel comprend en outre l'étape de régulation de la pression dans l'enceinte qui ne doit pas être supérieure à environ 532 N/m² (quatre torr).

9. Procédé selon la revendication 7, lequel comprend en outre l'étape de régulation de la pression dans l'enceinte qui doit être inférieure à environ 133 N/m² (1,0 torr).

10. Procédé selon la revendication 7, lequel comprend en outre l'étape d'introduction d'oxygène dans l'enceinte.

11. Procédé selon la revendication 10, lequel comprend en outre les étapes de :
- barbotage d'oxygène à travers un composé organosilicium liquide ;
- vaporisation du composé liquide organique dans l'oxygène pour donner le composé organosilicium gazeux ; et
- transport du composé organosilicium gazeux dans l'enceinte avec l'oxygène.

12. Procédé selon la revendication 7, lequel comprend en outre l'étape de création d'un plasma de façon à faire réagir les gaz introduits.

13. Procédé selon la revendication 7, lequel comprend en outre l'étape de dépôt du composé contenant du silicium en utilisant une méthode de dépôt chimique en phase vapeur à faible pression.

14. Procédé selon la revendication 7, lequel comprend en outre les étapes de :
- l'introduction du trifluorure d'azote dans l'enceinte dans des quantités comprises entre quatre et soixante-dix pour-cent en volume ; et
 - l'introduction du composé organosilicium gazeux dans l'enceinte dans des quantités comprises entre deux et soixante-dix pour-cent en volume ;
15. Procédé selon la revendication 7, lequel comprend en outre les étapes de :
- l'introduction d'un deuxième gaz contenant de l'azote dans l'enceinte ; et
 - le dépôt de la couche sur la pastille pour inclure un nitrure de silicium.
16. Procédé pour le dépôt d'une couche d'un composé contenant du silicium sur une surface de pastille ayant des caractéristiques topographiques d'un rapport d'aspect élevé comprenant les étapes de :
- la mise en place du support dans une enceinte mise sous une pression inférieure à environ 133 N/m² (un torr) ;
 - l'introduction d'un composé organosilicium gazeux dans l'enceinte ;
 - l'introduction de trifluorure d'azote dans l'enceinte ; et la mise en réaction du composé organosilicium avec le trifluorure d'azote pour déposer la couche du composé contenant du silicium sur la surface de telle façon que des vides dans la couche ne soient pas formés.
17. Procédé selon la revendication 16, et comprenant en outre l'étape de garnissage des caractéristiques topographiques sur la pastille ayant un rapport d'aspect supérieure ou égal à 1,0.
18. Procédé selon la revendication 16, et comprenant en outre l'étape d'introduction d'oxygène dans l'enceinte.
19. Procédé selon la revendication 16, et comprenant en outre l'étape d'introduction d'oxygène et de trifluorure d'azote dans l'enceinte dans un rapport volumétrique ne dépassant pas environ six à un.

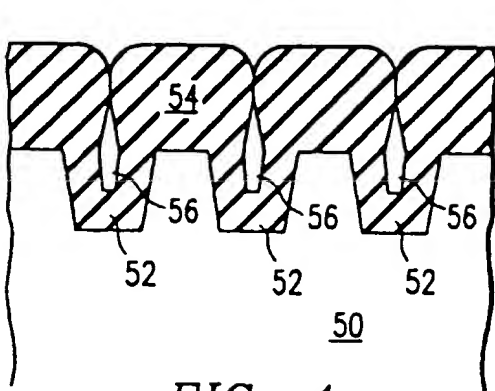
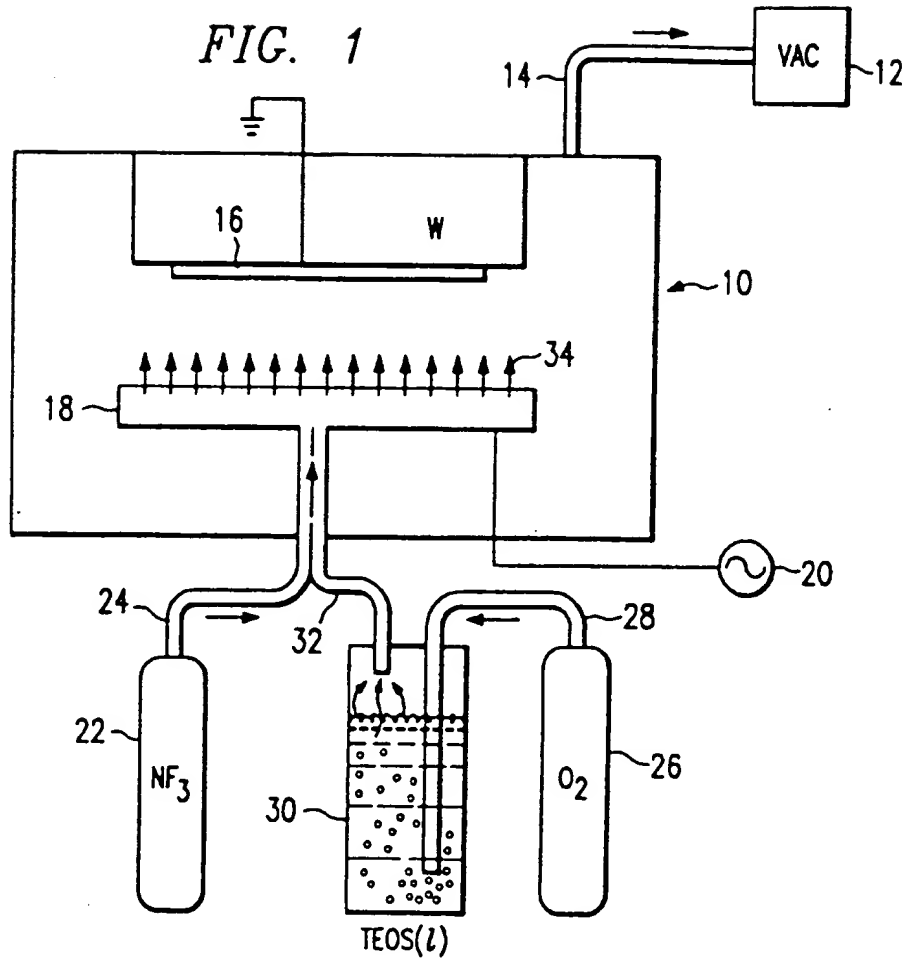


FIG. 4
(PRIOR ART)

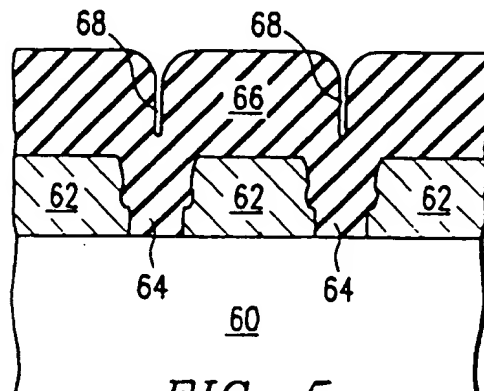


FIG. 5

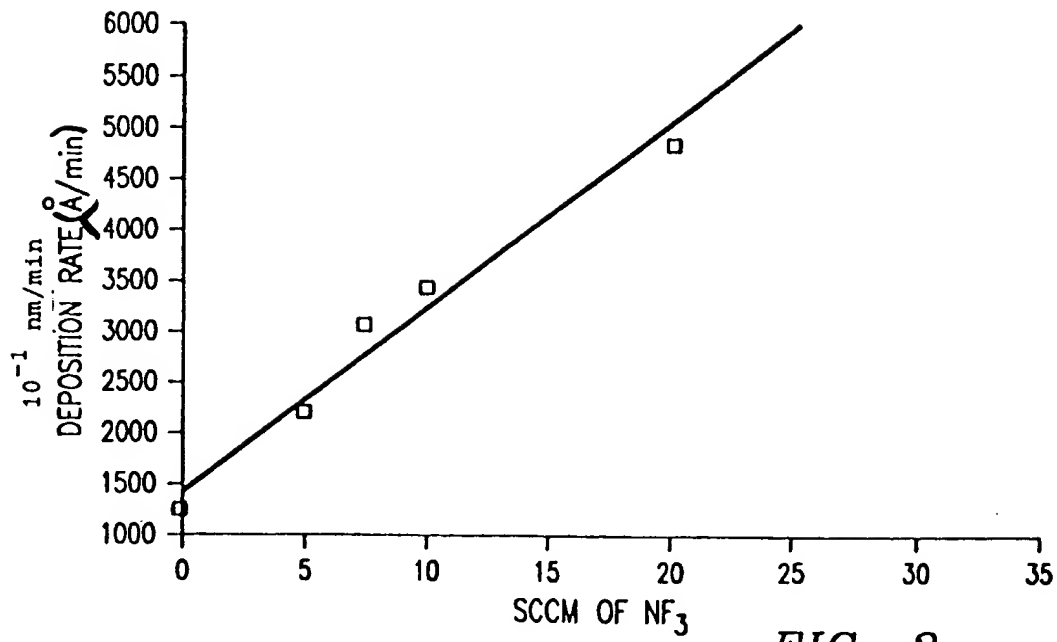


FIG. 2

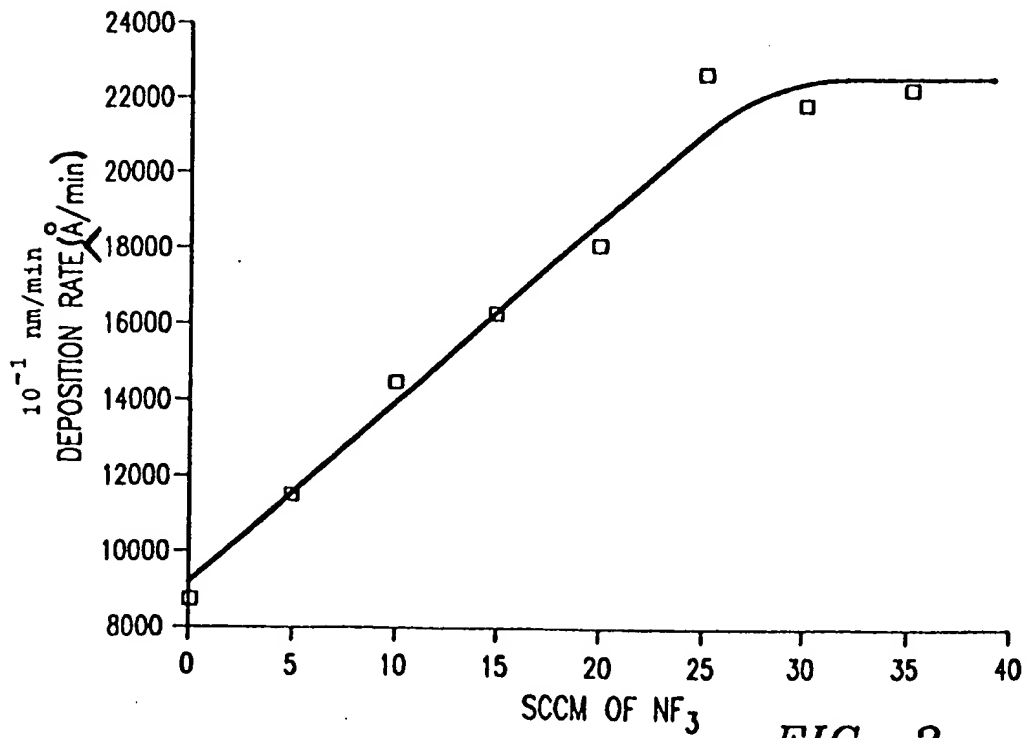


FIG. 3